NEAR DRY MACHINING

IAB Presentation

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OUTLINE

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  - Preliminary results at Georgia Tech
- PLAN OF STUDY
  - Tool wear model
  - Cutting fluid aerosol generation model
  - Experimental Calibration and Validation
- CONCLUSION

INTRODUCTION

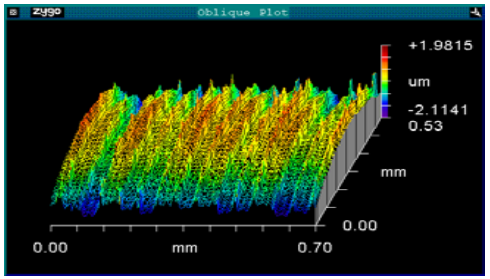
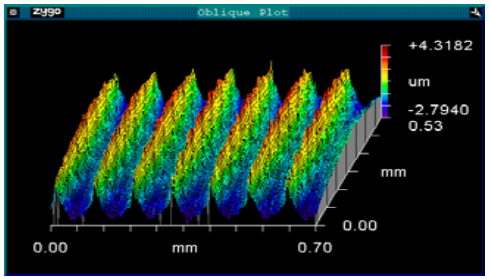
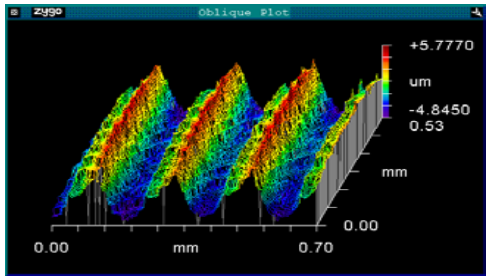
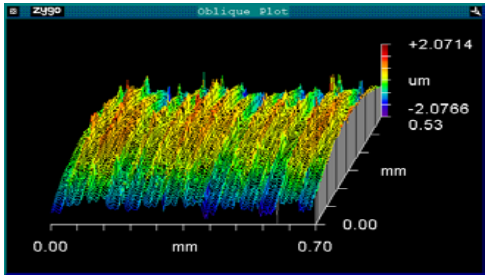
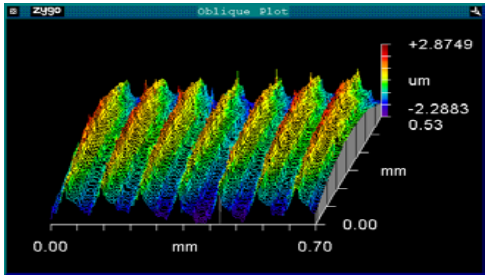
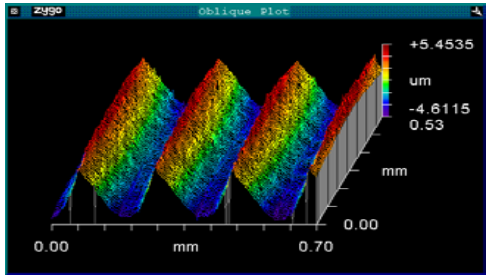
- Dry Machining vs. “Wet” Machining
- Benefits of Cutting Fluids
  - Cooling
  - Lubricating
  - Chip flushing
- Disadvantages of Cutting Fluids
  - Health
  - Environment
  - Cost
    - 20% of total manufacturing cost due to cutting fluids vs. 7.5% of total manufacturing cost due to cutting tools
- Near Dry Machining
  - A small amount of cutting fluid, typically lower than 50 ml/hr
  - Only empirical observations

INTEREST OF STUDY

- Tool Wear Analysis
  - Tool wear mechanism
- Surface Roughness
- Cutting Fluid Aerosol Generation Analysis
  - Aerosol generation mechanism
- Compare Near Dry Machining with Dry and “Wet” Machining
  - Temperature
  - Forces
  - Tool life
  - Surface roughness
  - Aerosol generation

PRELIMINARY RESULTS AT GEORGIA TECH(1)

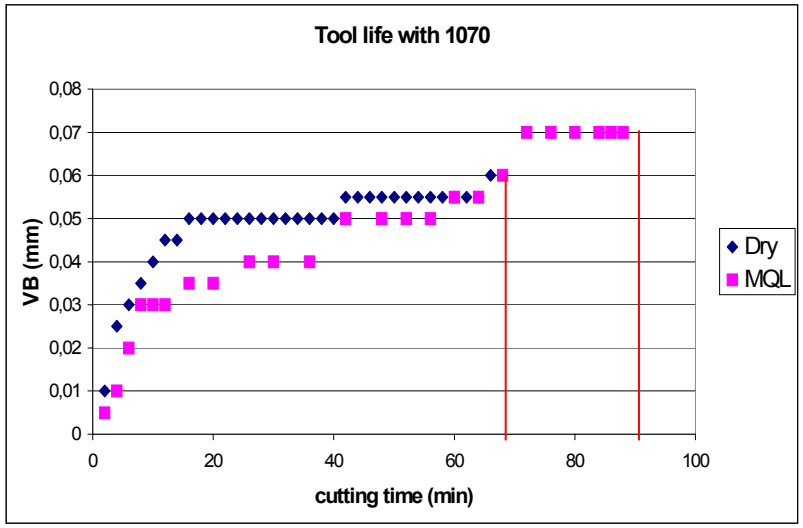
- Surface Profile Is Better, Roughness Smaller

f < 0.002	0.004 < f < 0.006	0.008 < f
Dry	Dry	Dry
		
MQL	MQL	MQL
		

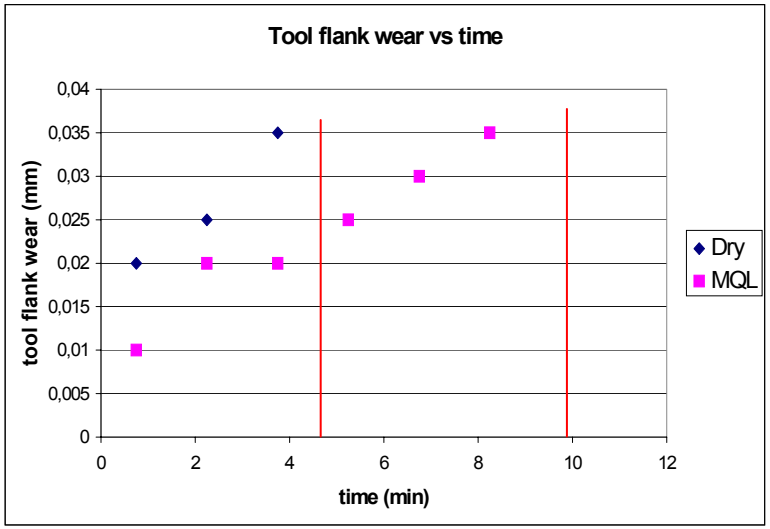
[Autret, 2002]

PRELIMINARY RESULTS AT GEORGIA TECH(2)

- Increases Tool Life



Vc500sfpm f0.004in/rev Ap0.012in

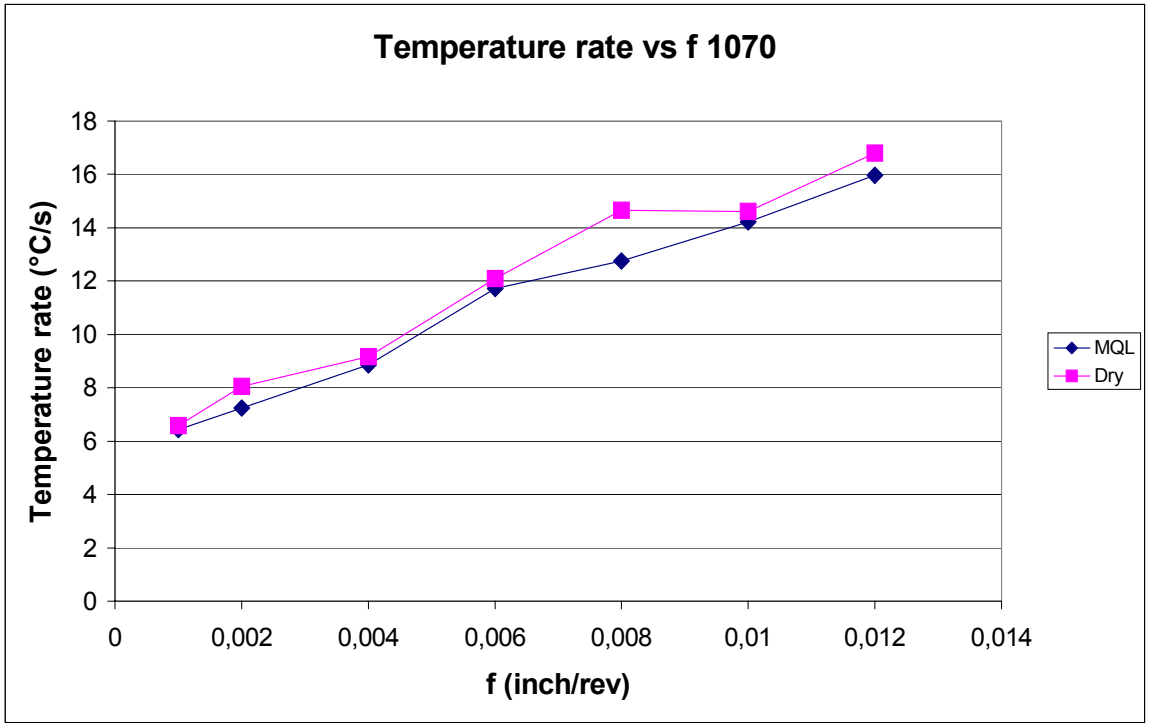


Vc700sfpm f0.008in/rev Ap0.01in

[Autret, 2002]

PRELIMINARY RESULTS AT GEORGIA TECH(3)

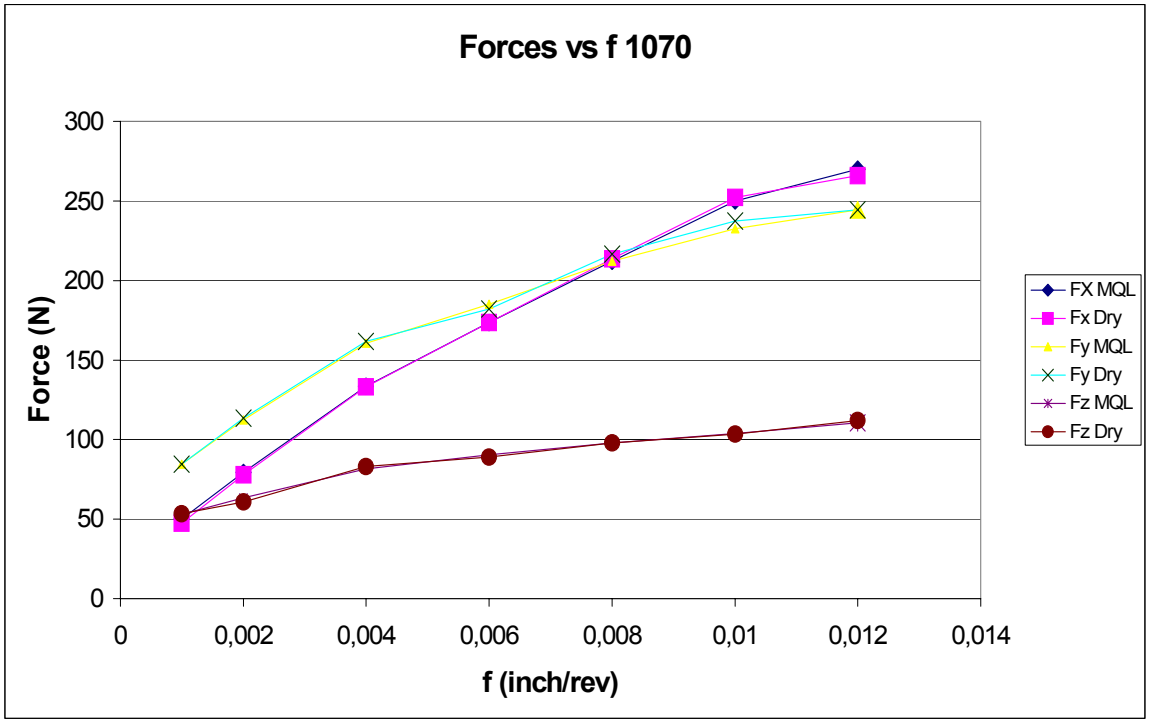
- Decreases Steady State Cutting Temperature



[Autret, 2002]

PRELIMINARY RESULTS AT GEORGIA TECH(4)

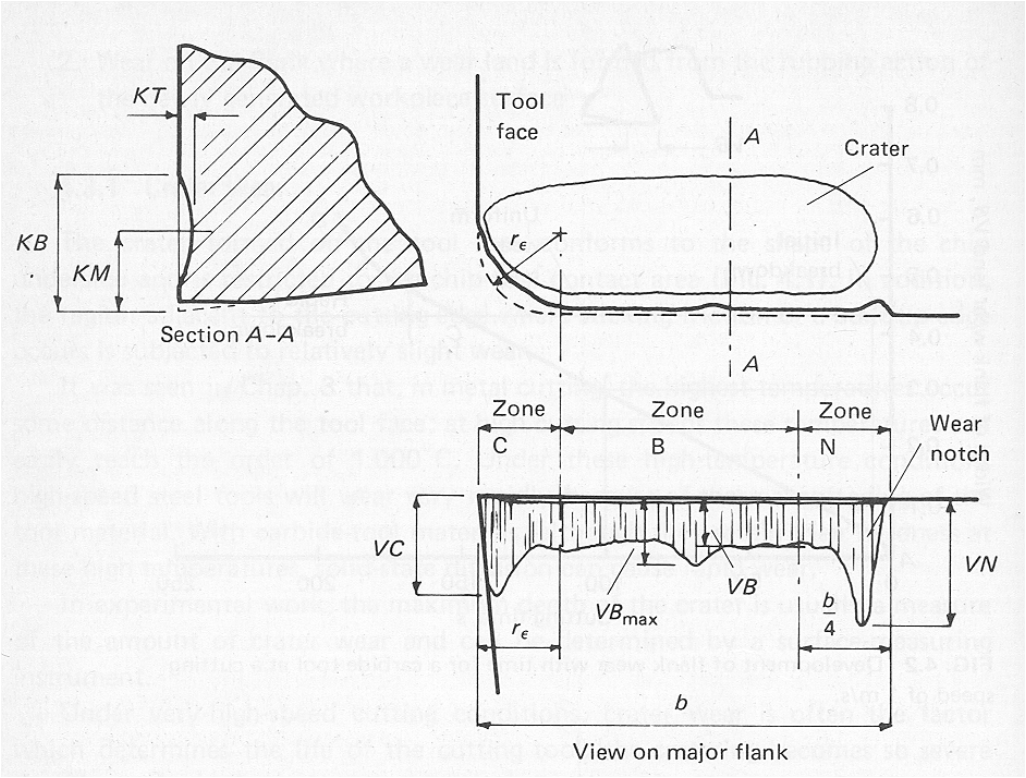
- Forces Are Close to Dry Machining



[Autret, 2002]

TOOL WEAR MODEL(1)

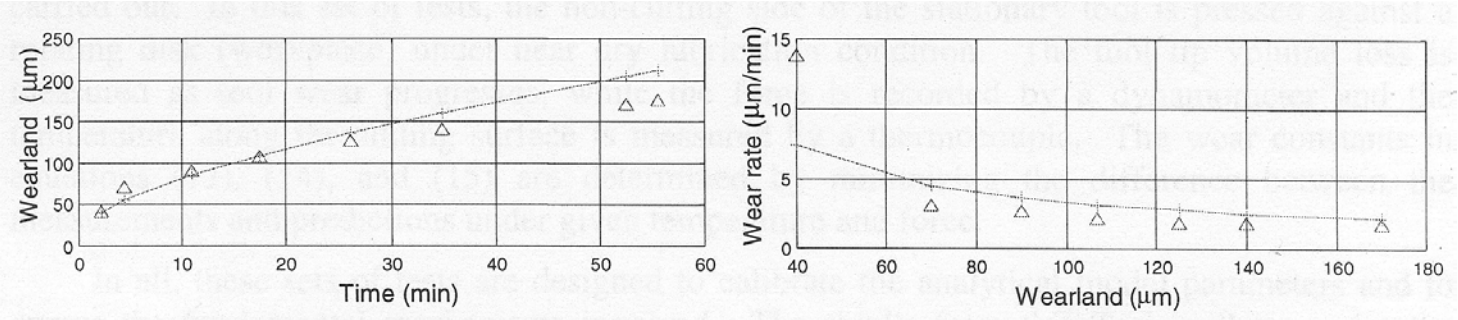
- Crater Wear
- Flank Wear



[Boothroyd, 1975]

TOOL WEAR MODEL(2)

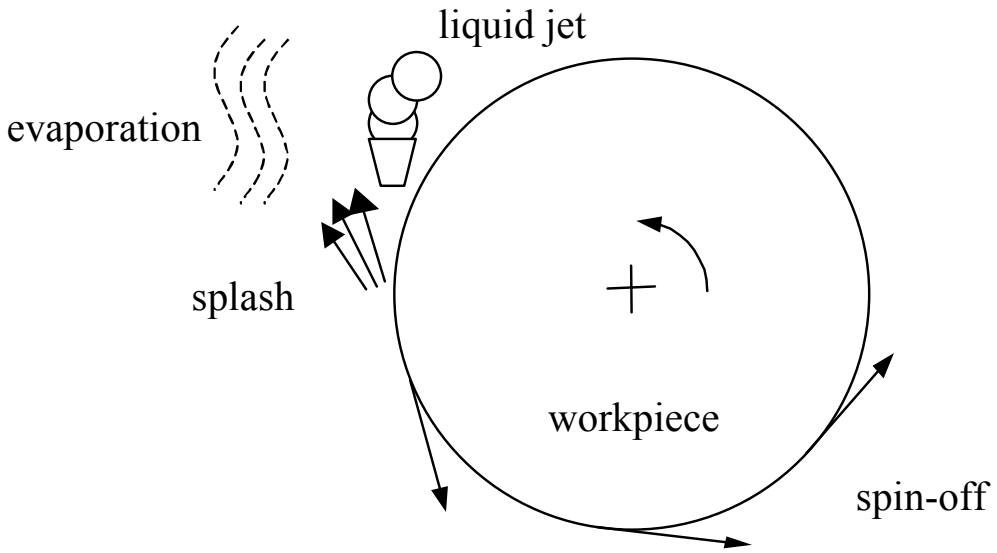
- Tool Wear Mechanism
  - Abrasive wear: $V_{wear-abrasion} = K_{abrasion} K \left(\frac{P_a^{n-1}}{P_t^n} \right) V_c w \overline{VB} \overline{\sigma} \Delta t$
  - Adhesive wear: $V_{wear-adhesion} = K_{adhesion} e^{aT} V_c w \overline{\sigma} \Delta t$
  - Diffusive wear: $V_{wear-diffusion} = K_{diffusion} \sqrt{V_c \overline{VB}} e^{\frac{-K_Q}{T+273}} w \Delta t$



[Huang, 2002]

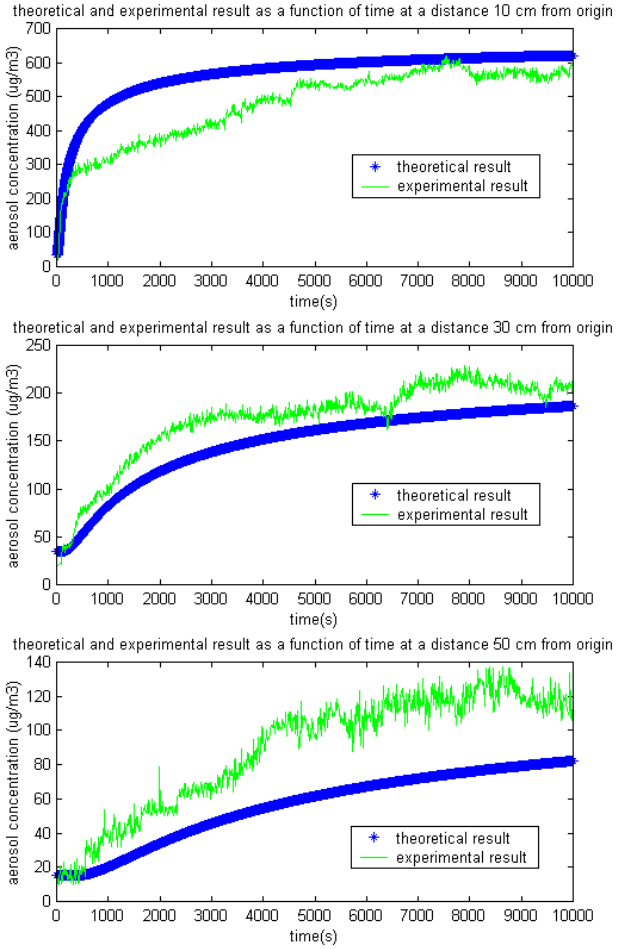
CUTTING FLUID AEROSOL GENERATION MODEL(1)

- Aerosol Generation Mechanism
  - Spin-off
  - Splash
  - Evaporation



[Chen, 2000]

CUTTING FLUID AEROSOL GENERATION MODEL(2)



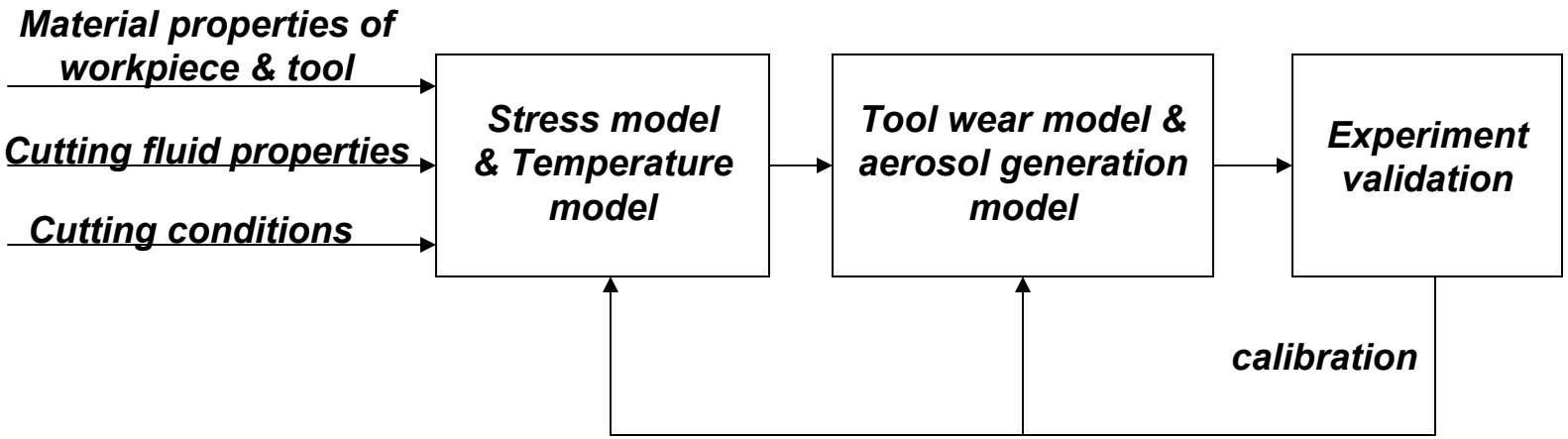
[Chen, 2000]

EXPERIMENTS CALIBRATION AND VALIDATION(1)

- Tool Wear Model Verification
  - Horizontal turning machine(CMS GT-27)
  - Pressurized tank fluid applicator (Unist Coolubricators system)
  - Dynamometer(Kistler 9275B)
  - Thermocouple(Omega Type K)
  - Profiler(Zygo NewView 200)
- Aerosol Generation Model Verification
  - Real-time aerosol monitor(DataRam 2000)
  - Aerosol spectrometer(PMS-CSASP-100)

EXPERIMENTS CALIBRATION AND VALIDATION(2)

CONCLUSION


Material properties of workpiece & tool
Cutting fluid properties
Cutting conditions
Stress model & Temperature model
Tool wear model & aerosol generation model
Experiment validation
calibration